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The Effects of Different Storage Buildings on Wheat Quality

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Abstract: The aim of storage is to preserve properties of products and their freshness. If suitable storage conditions are not supplied consistency product variety, quality and quantity losses increase. Decreasing this losses is possible with providing suitable storage condition and storage management. In this study, wheat storage buildings in the Thrace region were examined. Influences of storage condition on product losses were investigated. The study was conducted in one of the Soil Products Office's (TMO) reinforced concrete silo (RCSi) in Tekirdag, Reinforced Concrete Store (RCSt) and Masonry Stores (MS) in Hayrabolu district within the border of Tekirdag. Temperature of the wheat mass in the stores and moisture content as storage conditions, effective on quality parameters such as hectoliter, gluten, gluten index, sedimentation and sunn pest were monitored during the storage. According to the results of experiments in selected stores, the worst storage conditions and the most quality losses were determined in the MS, on the other hand the most suitable conditions and the least losses were determined in RCSi and RCSt. Consequently, the MS should be improved and aeration systems should be built in this store. This store can be used for shortage storage period. In the RCSi and RCSt stores, the aeration systems should be run properly.

Key words: Wheat storage, storage condition, wheat quality, quality losses

INTRODUCTION

Because of the nourishment necessity of population in the world, sources in the world must be used sustainably. Recently, increased farm production is based on obtaining more product from a unit area. However, processing and evaluating of these products are more important. Majority of farm products are consumed after the process. Hence, storage of products after the process until marketing is a necessity (Sisman, 2003).

Food both vegetable and animal origin undergoes some changes because of its structures when kept for long time. Therefore, storage or keeping food and food's raw materials without spoiling is vital. The aim of storage is to preserve properties of products and their freshness until marketing or consuming. Storage is done to maintain harvesting quality of products, not to improve it. The seed deterioration under storage condition is the natural phenomenon. If suitable storage conditions are not supplied according to product variety, quality and quantity losses increase (Nasreen, 2000; Sisman, 2005; Sisman and Albut, 2010).

The quality of grains during storage is affected by entomological, microbiological and environmental factors, resulting in physicochemical and organoleptic changes that lead to significant product qualitative and quantitative losses (Iconomou *et al.*, 2006). The losses of grain because of spoilage, sprouting, warming, insect and mold damages cost millions dollars per year during harvesting, carrying and storing. These losses and spoilage during storage can only be reduced by suitable storage and storage management and this leads to contribute to country economy. Sisman *et al.* (2004) reported that different storeges buildings which is effected to storage condition lead to increse of losses during storage.

The seeds continue the respiration after harvest in order to sustain their life. The respiration is the transformation of seed components into carbon dioxide by atmospheric oxidation. During this physiological process in the seed, the carbohydrates in the seed are disintegrated and water and heat are released. As a result of this, structural deterioration and heating in the seed can be occurred (Gumuskesen, 1999). Seed longevity is greatly influenced by storage conditions, such as relative humidity and temperature and lowering of these parameters significantly increases the storage life of seeds (Sharma *et al.*, 2007).

The temperatures in the store and moisture contents of the seed which are called as storage conditions are the most important factors affecting the losses. If suitable storage conditions are not supplied according to product

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variety, quality and quantity losses increase. Sisman and Delibas (2005) reported that the losses in the stored grain during storage in United State was determined to be approximately 1 million $ per year.

Nowadays, one of the most important food for human is grains because of high carbohydrate contains and hearty property. The wheat is most important grains which grown throughout the world. Wheat provides more nourishment than any other food grains. In its natural state, wheat is a good source of vitamin B1, B2, B6, niacin as well as iron and zinc besides being a cheap source of process and calories (Abid *et al*., 2009). In Turkey, the grains, especially wheat are widely used in flour production which is a main component of the bread (Anonymous, 2007).

Wheat producer and consumer countries in the world in 2009 and production shares are given in Fig. 1a and b.

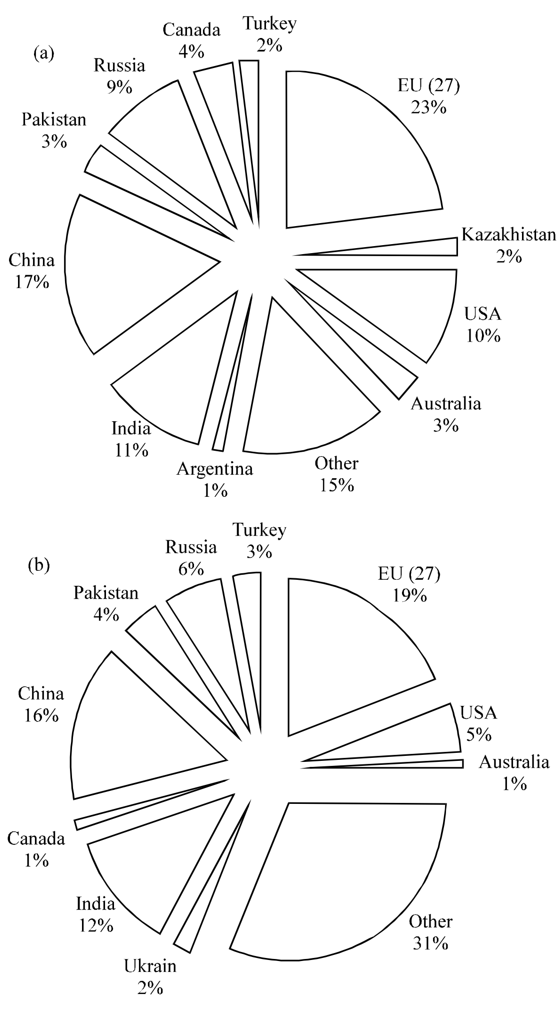

Fig. 1: Wheat producers of the world (a) and consumer countries (b) in 2010

The wheat production in the world is 688 million tons in 2010 and consumption is nearly 619 million tons. Turkey is the 8th largest wheat producer in the world with the average of 20.6 million tons and is 7th largest consumer country with 18.5 million tons (Anonymous, 2010).

The most important stocker of wheat in Turkey is the Soil Products Office (TMO). The TMO uses different types and capacities stores such as silo (concrete, steel), reinforced concrete store, masonry store, wood store etc. The wheat is usually stored as heaped in the TMO's stores.

The TMO has the reinforced concrete silo with 528000 t capacity, internal silo with 1300300 t capacity and reinforced store and mansory store with 1586000 t capacity, temporary store with 690000 t capacity and total storage capacity of TMO in Turkey is approximately 4104300 t (Anonymous, 2010).

The objective of this study is to investigate the present state of different wheat storage buildings in Thrace Region, to identify the reason effective for the losses during the storages and to suggest features of wheat storage buildings to minimize the losses.

MATERIALS AND METHODS

The study was carried out in Reinforced Concrete Silo (RCSi) in Tekirdag, Reinforced Concrete Store (RCSt) and Masonry Store (MS) in Hayrabolu district of the store of TMO. Wheat seeds were collected from these stores every month regularly during seven-month storage period started from September 2009 and all these collected samples were subjected the some quality analysis.

The RCSi was built as reinforced concrete with using high dosage and slip casing and it consisted of 70 grain silos each of which has a capacity of 1000 t. Each of these silos was 6.24 m diameter and 36.60 m height. The wheat was automatically loaded to store by tremiler and it was unloaded by bunker systems. Measurements of mass temperature and humidity in the stores were digital humidity/meter instrument weekly as triple replicated at four different point of each stores The measurements of mass temperature in these silos were automatically recorded using temperature sensors at 24 different of each silos. The RSCi has the automatic aeration system.

The RCSt was located in the center of Hayrabolu district. This store had total 10000 t capacity with 13.3 m in width, 100 m in length, 16.5 m in ridge pole of roof. In this store, reinforced concrete shear columns were built at 4.6 m intervals to resist safely to horizontal forces of the mass. The portable aeration ducts were replaced on the floor and the open areas in the roof for aeration were built along the ridge pole of roof.

The MS had total 1000 t capacity with 10 min width, 36 m in length, 6.5 m in ridge pole height. It was built in South-North direction and in the shape of joined (two pal). In this store reinforced concrete columns were connected to each other with reinforced concrete girders replaced onto and under the walls. The roof was built with steel lattice systems without the ceiling. The aeration in this store was done with doors and windows.

The temperature measurements were done at twenty four different points in RCSi with automatic temperature sensors and at twelve different point in the RCSt and MS with implemented probed measuring devices and also at two different depths, namely, at 25 and 75% of the mass depth. The temperature measurements in the stores were done every 15 days during the study.

Wheat samples were taken every month in the stores to determine the quality losses occurred in the stores during storage period. The samples were taken in four replications from the center and side of the stores and at two different depths, 25 and 75% of the mass depths. Partitioned hand probe was used for taking samples and the wheat samples of 3-4 kg taken from each store were filled into bags and brought to laboratory for analysis (Elgun and Ertugay, 1995).

Analyses of hectoliter, moisture content, gluten and gluten index, sedimentation and sunn pest value in the laboratory were done on the samples. The hectoliters weights of the samples were determined according to the method given in Anonymous (2009a, b).The moisture contents were determined on basis of dry weight according to Nas *et al*. (1998) and Anonymous (2009b). The gluten and gluten index were determined according to AACC 38-12 methods given in Ozkaya and Ozkaya (2005). The sedimentation was determined according to AACC 56-61 method given by Anonymous (2009b).

RESULTS AND DISCUSSION

Storage conditions: Changes in the outside temperature and the average mass temperatures during the storage period are presented in Fig. 2 for RCSi, RCSt, MS, respectively.

As shown in the Fig. 2, it was determined that the temperatures in each store were higher than the recommended values in literatures for safe storage. Brooker *et al*. (1992), Proctor (1994), Hofman and Hellevang (1997), Gregorie (1999), Hellevang (1995) and Sisman *et al*. (2004) suggested that temperature in wheat store should be close to outside temperature in storage period. Especially in the fall and spring, the temperature in the store should be lower than 16°C. Grains are normally

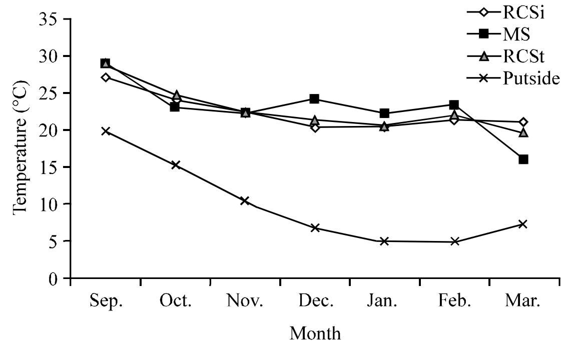

Fig. 2: Changes in the mass temperatures during the storage

placed in storage at temperatures much warmer than outside temperature. Since grain is good insulator, this temperature difference between mass and outside occur temperature differences within the grain mass. This temperature difference within the mass causes moisture migration (Hellevang, 1995; Sisman and Albut, 2010).

The reason of the high mass temperatures in the stores was continuously loading and unloading in these stores and ineffectively running of aeration system in RSCi and RCSt. This was attributed to the increase in the mass temperature causing to rise in the crop respiration (Sisman and Delibas, 2005).

When the stores were compared, the most suitable mass temperatures for safe storage during storage were recorded in RCSi and RCSt and the worst mass temperatures were recorded in MS. This is because an aeration systems exists in RCSi and RCSt. In winter, the mass temperatures in MS increased due to lack of aeration system. Reed and Harner (1998) reported that the aeration system in the winter should be run periodically for a day or two during good weather when the outside temperature is near the temperature of the grain.

Wheat quality

Hectoliter weight: Hectoliter weight is a quality parameter which provides information about fullness of kernel in world standard classifications (Sehirali, 1997). Average hectoliter weight for wheat flour used in bread in Turkey is 78.0 kg and minimum hectoliter weight is 72.0 kg (Anonymous, 2009a).

The results of hectoliter analysis of the samples taken from the stores are given in Fig. 3. The hectoliter weight of 81.2 kg at the beginning of storage in RCSi was almost unchanged until the end of the storage period. The hectoliter weights in RCSt and MS reduced from 81.4 to 79.6 kg and from 81.8 to 72.0 kg, respectively. The

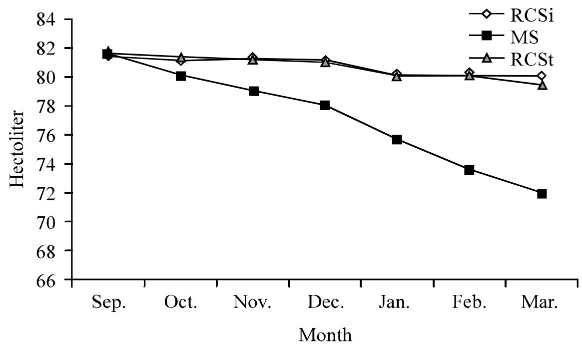

Fig. 3: Changes in the hectoliter weight during the storage

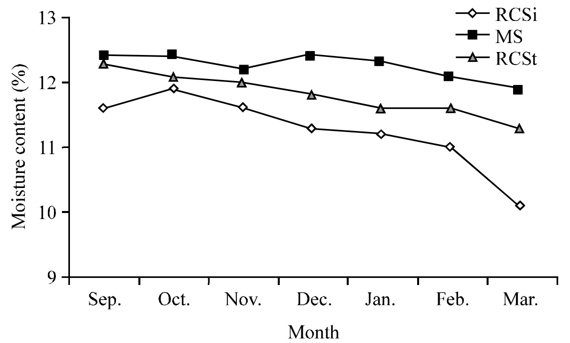

Fig. 4: Changes in the moisture content of the wheat during the storage

hectoliter weight in MS at the end of storage was lower than the minimum weight for wheat flour given by Anonymous (2009a).

Moisture content: The moisture content is one of the most important features that affect the quality of the grains. The results of the moisture content analysis of the samples taken from the stores on a monthly regular base were given in Fig. 4.

When the moisture content changes in were investigated, it was seen the moisture content of RCSi decreased from 11.6 to 10.9% during storage from September to March (Fig. 5). This 1.5% decrease was attributed to aeration. Sisman (2003) reported that the moisture content of the stored product can be reduced by aeration. When mass temperature and the moisture content were evaluated together, it was seen that the moisture content decreased unexpectedly. The reason of this decrease was continuously loading and unloading during storage. This fact restricted evaluation of the moisture content changes in this store accurately.

Sisman and Albut (2010) recommended that moisture content of wheat for safe storage should not exceed 8-14%. If wheat moisture content exceeds 16%, it may cause both increase in temperature due to respiration and increase in damages of fungi and mycotoxin on the wheat. The maximum activation of the mycotoxin is occurred in 17-18% moisture content (Daglioglu and Gumus, 1996). The moisture contents of wheat in RCSi during storage were remained below these values.

When the results of the moisture content of the samples taken from the RCSt are examined, it was observed that the moisture content of 12.3% in September decreased to 11.3% in March. This decrease of 1% was resulted from aeration and of continuously loading and unloading during storage.

The moisture content in MS decreased from 12.4 to 11.3% during storage period due to keeping the door and the windows of the store opened o (Fig. 4). But the moisture content in the winter increased because of keeping the door and the windows closed. In the spring, the moisture content decreased again because of opening the doors and windows.

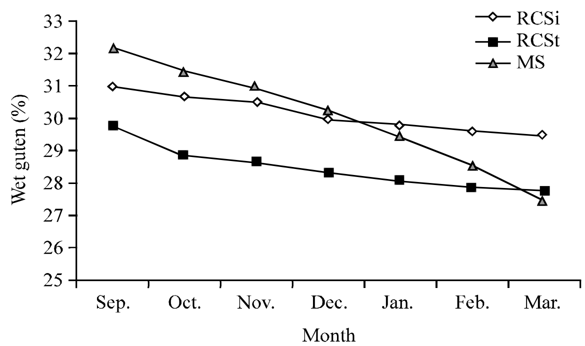

Fig. 5: Changes in the wet gluten percentage during the storage

As shown in the Fig. 4, when the moisture content of the three different storage products compared with each other, the highest decrease in moisture content was in RCSi and the least was in the MS. However, the moisture contents of the wheat samples in three stores were below the recommended moisture content (14%) for safe storage. This situation clearly demonstrated the importance of aeration systems in the stores.

Wet gluten: The wet gluten which affects protein quality was classified into four classes by Ozkaya and Ozkaya (2005). The first class is called very good with wet gluten greater than 35%, the second is called good with wet gluten between 28 and 35%, the next is called medium with wet gluten between 22 and 27% and the last one is called low with wet gluten less than 20%.

The wet gluten was determined by regularly done analysis on the sample taken from the stores and changes in the gluten percentage with time are presented in Fig. 5.

The wet gluten in the RCSi decreased gradually from about 31.0% in September to 29.5% in March towards the end of the storage (Fig. 5). This result showed that the wheat in this store were classified as good in terms of wet gluten class although total wet gluten loss during storage was 2.5%.

The wet gluten in the RCSt decreased from about 29.8% in September to 27.8% in March towards the end of the storage. The total wet gluten loss during storage was determined as 2.0%. While the wheat in the RCSt was in good wet gluten class at the beginning of the storage, it changed to middle class at the end of storage.

The wet gluten in the MS decreased from about 32.2 to 27.5% during storage. The highest wet gluten loss was determined in this store with 4.7% decrease. The wheat in the MS in good wet gluten class at beginning of the storage became middle class at the end of storage. The high moisture content and temperature were the reasons of the maximum wet gluten loss in MS.

Dizlek and Gul (2007) reported that the low wet gluten percentage causes some problems in producing of the flour and bread such as low water absorption and the bread volume.

Gluten index: Ozkaya and Ozkaya (2005) stated that the gluten index was one of the quality features of wheat. They classified into four categories according to gluten index. The first category is termed as poor with gluten index lower than 50%. The second category is moderate with between 51-70%. The third category is strong with between 70-85% and the last category is very strong with higher than 86%.

The gluten index was determined by regularly done analysis on the sample taken from the stores and changes in the gluten index with time are presented in Fig. 6.

It can be seen from Fig. 6 that the gluten index in RCSi decreased from 92 to 89% during the storage. The gluten index in RCSi remained in very strong gluten index class despite the decrease of 3%. The gluten index in RCSt decreased from 94 to 87% and remained in very strong gluten index class as well. In the MS, the gluten index decreased from 96 to 84%. The gluten index with a decrease of 12% in this store took part in strong class. High moisture content of the wheat in store caused this decrease. Perten (1990) recommended that gluten index for bread wheat should be at least 60%. Dizlek and Gul (2007) reported that if the gluten index is less than 60%, some problem in making bread such as dough spreads and gas holding capacity can occur.

Sedimentation: Sedimentation which provides information about the quality of the wheat is an important parameter. It is classified into three categories according to Anonymous (2009b); Medium (less than 20 mL), Good (25-30 mL) and Very good (higher than 30 mL).

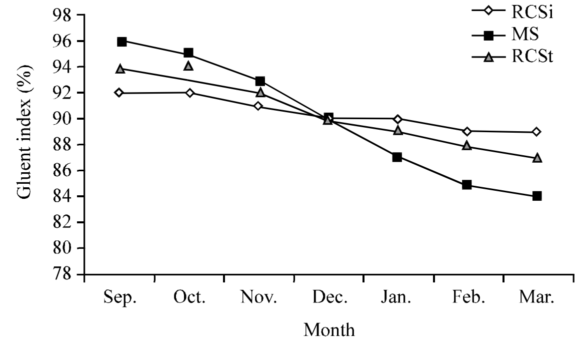

Fig. 6: Changes in the gluten index during the storage

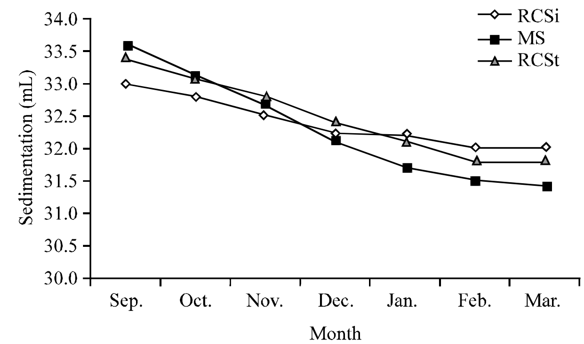

Fig. 7: Changes in the sedimentation during the storage

The changes of sedimentation analysis results of the wheat samples taken from the stores are given in Fig. 7.

As seen in Fig. 7, the sedimentation values in the RCSi, RCSt and Ms decreased continuously during the storage but all of them remained in very good class. The relatively less losses occurred in RSCi with 1.0 mL when compared with the others and the highest loss was in MS with 3.2 mL.

Sunn pest: Sunn pest attacks after the milk stage of wheat causing shriveling, reduced starch content and lower grain weight. This causes in direct damage to yield and viability of wheat. In addition, the salivary protein enzymes injected into the wheat cause destruction of gluten and the favorable baking properties of flour which results in rapid relaxation of dough and poor volume and texture of loaves (Kinaci and Kinaci, 2004). The sunn pest percentage was determined by analysis done regularly on the sample taken from the stores. The changes in the sunn pest with time are presented in Fig. 8.

As seen in the Fig. 8, the sunn pest percentage in the CSi, RCSt and MS during storage increased from 2.0 to 2.1%, from 1.97 to 2.07% and from 1.88 to 2.09%,

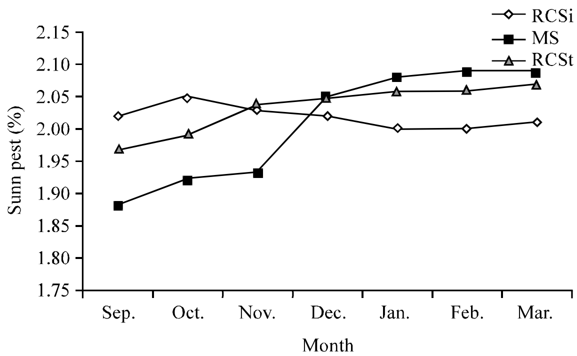

Fig. 8: Changes in the sunn pest during the storage

respectively. The highest increase in sunn pest percentage occurred in MS with 0.21% which was resulted from the high moisture content and temperature in this store.

CONCLUSION AND RECOMMENDATION

In this study conducted in Tekirdag having a significant share of wheat production, influences of storage conditions on the quality losses occurred during storage of different storage buildings used for wheat were investigated.

According to the results of experiments in the selected stores, the mass temperatures in the stores during storage were quite higher than the recommended values. The mass temperature is one of the most important environmental factors because it affects both of the insects and pests activities and mold and fungal growth which deteriorates of the wheat quality. In addition, the toxic metabolite secreted by mold threatens to the human and animal health (Saglam, 2008).

Aeration greatly improves the storability of grain by maintaining a cool, uniform temperature throughout the storage to reduced mold growth and insect activity and to prevent moisture migration. The lack of aeration system or insufficient running of the aeration system caused to increase of losses through the increase of the temperature and moisture content during storage. The RCSi and RCSt investigated in this study had the aeration system but it was determined that the aeration systems did not run effectively. Hellevang (2000) recommended that the aeration is started to reduce the grain temperature when the average outdoor temperature is about 6 to 8°C lower than the grain temperature. Aeration is stopped when the grain temperature is equal to outdoor temperature.

The MS was determined as the worst store in terms of storage conditions and losses among the investigated sores. This fact was due to the high temperature caused by lack of aeration system.

Present MS must be improved and first of all aeration system must be constructed. Aeration of the existing concrete stores may be founded by means of establishing fans located on short side wall in the store and perforated ducts settled on the floor. Fan capacity, air velocity, cross sectional aria of ducts and duct arrangement, size of open aria in the roof, how much and when the aeration will be done are important.

The airflow rate and uniform airflow distribution are very important for an effective aeration. The airflow rate and airflow distribution system are determined depending on the store capacity. Airflow rate must be supplied minimum 0.08 m^3 min^{-1} and maximum 0.8 m^3 min^{-1} for each cubic meter grain (Proctor, 1994; Yuksel and Sisman, 2000; Sisman, 2005).

The moisture content of the wheat to be stored must be between 8-14%, depending on the storage duration and shall be reduced as the storage time increases (Sisman and Albut, 2010). Before the wheat is placed into the store, foreign materials, cracked and broken wheat should be cleaned to reduced mold and insect attack. The amount of the foreign materials should be reduced to a value of lower than 4% (Shelton *et al*., 1998; Sisman *et al*., 2004).

REFERENCES

Abid, H., J. Ali and A. Hussain, 2009. Suitability of different wheat varieties grown in NWFP for bread making and effect of storage time on falling number. Pak. J. Nutr., 8: 616-619.

Anonymous, 2007. 2007 cereal report. Soil Products Office. Ankara, Turkey.

Anonymous, 2009a. The measurements in wheat analyses lab. Toprakcan Flour and Food Industrial Trade Anonymous Company.

Anonymous, 2009b. Wheat quality. TS 2974, Institute of Turkish Standards, Ankara, pp: 18.

Anonymous, 2010. 2010 cereal report. Soil Products Office, Ankara, Turkey.

Brooker, D.B., F.B. Arkema and C.W. Hall, 1992. Drying and Storage of Grains and Oilseeds. Van Nostrand Reinhold, New York, ISBN: 0-442-20515-5.

Daglioglu, O. and T. Gumus, 1996. Mycotoxin problem in grains. Flour Prod. World, 5: 14-26.

Dizlek, H. and H. Gul, 2007. Improvement of the bread quality made from sunn pest (*Eurygaster* spp.) damaged wheat flours. J. Agric. Faculty Uludag Univ., 21: 51-58.

Elgun, A. and Z. Ertugay, 1995. Grain Processing Technology. Ataturk University Publisher, Ataturk, Turkey..

Gregorie, T., 1999. Storing wet sunflower. Procrop 2001, NDSU Extension Service, ND 58301-0477, USA.

Gumuskesen, A.S., 1999. Herbal Oil Technology. Asia Medical Publishing Ltd. Co., London, pp: 1-15.

Hellevang, K.J., 1995. Grain moisture content effects and management. NDSU Extension Service, AE-905, North Dakota, USA., pp: 9. http://www.ag.ndsu.edu/pubs/plantsci/crops/ae905w.htm.

Hellevang, K.J., 2000. Grain Moisture Content Effects and Management. NDSU, North Dakota, USA.

Hofman, V.L. and K.J. Hellewang, 1997. Harvesting Drying and Storage of Sunflower. In: Sunflower Technology and Production, Schneiter, A.A. (Ed.). American Society of Agronomy and Soil Science Society of American, Madison, WI., USA.

Iconomou, D., P. Athanasopoulos, D. Arapoglou, T. Varzakas and N. Christopoulou, 2006. Cereal quality characteristics as affected by controlled atmospheric storage conditions. Am. J. Food Technol., 1: 149-157.

Kinaci, E. and G. Kinaci, 2004. Quality and yield losses due to sunn pest (*Hemiptera*: Scutelleridae) in different wheat types in Turkey. Field Crops Res., 89: 187-195.

Nas, S., H.Y. Gokalp, M. Unsal, 1998. Herbal Oil Technology. Pamukkale University Engineering Faculty Book Publication, Denizli, Turkey, pp: 329.

Nasreen, S., 2000. Effects of storage temperature, storage period and seed moisture content on seed viability of mash bean (*Vigna mungo*). Pak. J. Biol. Sci., 3: 513-514.

Ozkaya, H. and B. Ozkaya, 2005. Analyses Method of Grain and Grain Products. Food Technology Publication, Ankara, Turkey, pp: 157.

Perten, H., 1990. Rapid measurement of wet gluten quality by the gluten index. Cereal Foods World, 35: 401-402.

Proctor, D.L., 1994. Grain Storage Techniques: Evolution and Trends in Developing Countries. FAO, Rome, ISBN 92-5-103456-7.

Reed, C. and J. Harner, 1998. Thermostatically controlled aeration for insect control in stored hard red winter wheat. Applied Eng. Agric., 14: 501-505.

Saglam, M., 2008. Inhibition effect of plasma application to fungi which found in cereals and legumes at storage stage. M.Sc. Thesis, Institute of Natural and Applied Science, Suleyman Demirel University, Isparta, Turkey.

Sehirali, S., 1997. Seed and Technology. Ankara University Printing House, Ankara, Turkey.

Sharma, S., S. Gambhir and S.K. Munshi, 2007. Changes in lipid and carbohydrate composition of germinating soybean seeds under different storage conditions. Asian J. Plant Sci., 6: 502-507.

Shelton, D.P., K.J. Jarvi and D.D. Jones, 1998. Initial condition determines quality of stored grain. Stored Grain In-Service Training Notebook, University of Nebraska Cooperative Extension, http://lancaster.unl.edu/ag/crops/inservice/Initial-i98.html.

Sisman, C.B., 2003. Storage of the grain. J. Turk-Koop Ekin, 7: 73-77.

Sisman, C.B., L. Delibas and G. Cicek, 2004. Temporary sunflower seed stores and quality losses during storage. Pak. J. Biol. Sci., 7: 812-821.

Sisman, C.B., 2005. Quality losses in temporary sunflower seed stores and influances of storage conditions on quality losses during storage. J. Cent. Eur. Agric., 6: 143-150.

Sisman, C.B. and L. Delibas, 2005. Storing sunflower seeds and quality losses during storage. Helia, 28: 115-132.

Sisman, CB. and S. Albut, 2010. Grain storage management. Proceedings of 3rd Annual International Sympsium on Agriculture Research, July 15-18, Athens, Greece, pp: 1-71.

Yuksel, A.N. and C.B. Sisman, 2000. Agricultural Construction. Trakya University Agricultural Faculty Publication, Turkey, pp: 156.